

# **EXPRESS Payload Integration Agreement for Alpha Magnetic Spectrometer (AMS-02) Crew Operations Post (ACOP)**

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## **International Space Station Program**

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– Preliminary Version**

**National Aeronautics and Space Administration  
International Space Station Program  
Johnson Space Center  
Houston, Texas**



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## **PREFACE**

### **INTERNATIONAL SPACE STATION PROGRAM EXPRESS PAYLOAD INTEGRATION AGREEMENT FOR AMS-02 CREW OPERATIONS POST (ACOP)**

The AMS-02 Crew Operations Post (ACOP) payload is the critical pressurized component of the truss-mounted AMS-02 payload and is required to protect AMS-02 mission success. This EXPRESS Payload Integration Agreement (PIA) documents the joint agreements to manage and execute the roles and responsibilities of the technical integration requirements, processes, services, and resources between the Alpha Magnetic Spectrometer-02 (AMS-02) Project, represented by the Johnson Space Center (JSC) Engineering Directorate AMS-02 Project Manager, and the International Space Station (ISS) Program, represented by the Space Station Payloads Office. These agreements include transportation services to and from ISS for the ACOP payload and its operational requirements once installed onboard ISS.

This PIA, along with SSP 57066, "Standard Payload Integration Agreement for EXPRESS/WORF Rack Payloads", defines the management agreements by both parties to the requirements documented within SSP 57066. This payload-unique PIA results in: (1) a co-signed PIA that addresses management agreements where they deviate from the SPIA; and, (2) the PIA provides direction to the applicable documentation, so that the Payload Developer (PD) shall be in compliance with the latest revision of SSP 57066. This PIA will be considered the binding agreement between the PD and the ISS Program Space Station Payloads Office for meeting and implementing the latest technical integration requirements and management processes required to fly a payload on the International Space Station

While the AMS Collaboration is responsible for developing the ACOP requirements and payload hardware, the JSC AMS-02 Project Office is providing project management direction and oversight for the ACOP payload development and schedules. The JSC AMS-02 Project Office will also function as the (PD) representative with signature authority for this PIA. The truss-mounted AMS-02 agreements are documented under a separate PIA for unpressurized payloads (JSC-57113).

The ACOP payload will be transported to ISS in pressurized passive stowage 3 to 6 months before the truss-mounted AMS-02 payload component is installed. The payload intends to design to meet the manifest requirements of the planned ISS logistics-carrying vehicles, including Shuttle, Progress, Soyuz, ATV, and HTV. The additional applicable requirements are documented within this PIA.

All commitments and services to be furnished by the ISS Program to the PD under this PIA shall be furnished using its best efforts.



**INTERNATIONAL SPACE STATION PROGRAM  
EXPRESS PAYLOAD INTEGRATION AGREEMENT  
FOR AMS-02 CREW OPERATIONS POST (ACOP)**

**APPROVAL**

**{DATE}**

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**INTERNATIONAL SPACE STATION PROGRAM**  
**EXPRESS PAYLOAD INTEGRATION AGREEMENT**  
**FOR AMS-02 CREW OPERATIONS POST (ACOP)**

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## **1.0 PURPOSE AND SCOPE**

This Payload Integration Agreement (PIA) documents the agreements to manage and execute the roles and responsibilities of the technical integration requirements processes, services, and resources between the Johnson Space Center (JSC) Alpha Magnetic Spectrometer-02 (AMS-02) Project Office and the International Space Station (ISS) Program for transportation services to and from ISS, and for on-orbit ISS resources and operations of the AMS-02 Crew Operations Post (ACOP). The effectivity of this co-signed PIA commences upon the last required signature of this document and continues through the end of the nominal AMS-02 mission as documented in the AMS-02 PIA (JSC-57113).

The PIA, with any unique agreements or exceptions, takes precedence over the generic agreements documented in ISS Program SSP 57066, Standard Payload Integration Agreement for EXPRESS/WORF Payloads (SPIA).

## **2.0 REQUIREMENTS**

The AMS-02 Project Office shall be in compliance with the latest revision of the applicable SPIA. Payload compliance is considered the primary step toward certification of the payload for flight. It is the responsibility of the AMS-02 Project Office to verify compatibility of payload physical and functional interfaces with the applicable EXPRESS interface agreements and documents. All payload physical and functional compliance shall be accomplished prior to installation for flight. Similarly, the ISS Program is responsible for verifying ISS interface compliance prior to payload transportation. The payload shall be in compliance with this PIA, the SPIA, and any updates directed by the ISS Program Payloads Control Board (PCB). This PIA, with any unique exceptions, takes precedence and/or supercedes those requirements baselined in the SPIA.

To facilitate delivery or return of the payload aboard a Russian vehicle, the payload shall meet the intent of the requirements specified in the Russian requirements document P-32928-103, "Requirements for International Partner Cargoes Transported on Russian Progress and Soyuz Vehicles." To facilitate delivery or return of the payload aboard a European Space Agency (ESA) vehicle, the payload shall meet the intent of the requirements specified in OPS-IDD-0-200, "ATV Dry Cargo Integration Interface Definition Document."

The PIA requirements source for the payload basic SPIA, Payload Data Sets, Interface Definition Document (IDD), and other applicable technical requirements and processes are shown in Section 2.1, Applicable Documents. The Section 2.2, Reference Documents, also provides payload-unique references above those documented in the SSP 57066 document.

### **2.1 APPLICABLE DOCUMENTS**

The applicable documents listed below are in addition to the documents specified by Section 2.1 of the SPIA, SSP 57066.

SSP 57066	Standard Payload Integration Agreement for EXPRESS/WORF Rack Payloads
P-32928-103	Requirements for International Partner Cargoes Transported on Russian Progress and Soyuz Vehicles
OPS-IDD-0-200	ATV Dry Cargo Integration Interface Definition Document

## 2.2 REFERENCE DOCUMENTS

The reference documents listed below are in addition to the documents specified by Section 2.2 of the SPIA, SSP 57066.

JSC-57113	Alpha Magnetic Spectrometer-02 (AMS-02) Payload Integration Agreement
SSP 57213	Alpha Magnetic Spectrometer-02 (AMS-02) Hardware Interface Control Document (ICD)
NSTS 21507	Space Shuttle Mission Integration Plan (MIP) for UF4
SSP TBD	Alpha Magnetic Spectrometer-02 (AMS-02) Crew Operations Post (ACOP) Hardware Interface Control Document (ICD)

## 3.0 JOINT AGREEMENTS

This PIA establishes the basic joint working agreements between the JSC AMS Project Office (representing the AMS-02 Collaboration) and the ISS Program Space Station Payloads Office to provide for integration/analyses, transportation services, installation, and command and data handling of the ACOP payload.

These joint agreements are documented in this payload-unique PIA, the SPIA (standard requirements), the Payload Data Sets (detailed technical requirements), the Interface Control Documents (hardware and/or software interface definition to ensure compatibility with the ISS and Space Shuttle), and the Payload Verification Plan (verification activities to ensure requirements are satisfied).

## 4.0 PAYLOAD DESCRIPTION



The ACOP payload is an EXPRESS sub-rack single middeck locker equivalent payload supporting the truss-mounted AMS-02 payload operations during the nominal three-year AMS-02 mission. ACOP will be launched to ISS by Shuttle (preferred) or another Earth-to-orbit vehicle (ETOV) logistics resupply vehicle and will be installed in a continuously powered EXPRESS Rack onboard the ISS. This transport to ISS will be in a pressurized passive stowage mode 3-to-6 months before the truss-mounted AMS-02 payload external component is launched to station.

ACOP provides the following critical capabilities to the AMS-02 experiment:

- a) Storage and downlink playback of data from AMS-02.
- b) Storage of files and programs to be uploaded into AMS-02 control equipments.
- c) Logging of the received ACOP telemetry and the commands to AMS-02.
- d) ACOP shall also be capable to issue commands for controlling AMS-02 internal functions and to visualize and monitor ACOP and AMS-02 telemetry data.

The AMS-02 Project requirement is for two (2) ACOP flight units on ISS with their required ancillary equipment volume and upmass. One ACOP flight unit shall be installed into a continuous powered EXPRESS subrack locker providing 24 hour x 7-day operations for the nominal AMS-02 3-year mission duration. The ACOP payload does require non-standard fiber-optic connections from the faceplate of the payload to two Utility Interface Panel J7 High Rate Data Link (HRDL) ports. The second ACOP flight unit may be soft stowed on ISS in a cold, unplugged condition. The payload also provides software that can run on the Express Rack Laptop Computer.

One (1) middeck locker equivalent of soft stowage is also needed for the payload's recording media and equipment spares.

During on-orbit operation, the ACOP requires periodic crew intervention for replacement of hard drives, and any required troubleshooting and replacement of faulty hardware from a set of pre-positioned logistics spares. The crew may also use ACOP to issue commands to the AMS-02 payload for operations or off-nominal situations.

## **5.0 UNIQUE AGREEMENTS, CONSTRAINTS, OR SERVICES**

- 5.1 ACOP is flown in support of the AMS-02 truss attached experiment covered under separate PIA (SSP 57113). SSP 57113 discusses the baseline requirements for ACOP and the interrelationship between the two components of the payload. For ACOP, this PIA document supercedes any SSP 57113 requirements.
- 5.2 ACOP requires physical connection to two (2) transmit (output) and one (1) (input) receive fibers (nominally via two (2) Utility Interface Panel (UIP) J7 connectors) for

the entire duration of the nominal AMS mission (not less than three years). These two non-standard ACOP fiber optic cables and connectors required for the UIP interface connections between the ISS rack locker and the ISS UIP will be furnished by AMS-02 Project as payload provided flight support equipment, and will be certified by the AMS-02 Project. Two (2) of these dedicated-fibers are for Automatic Payload Switch (APS) logical connections to link the AMS-02 High Rate Data Link (HRDL) transmit and receive paths to and from ACOP. The remaining transmit fiber link to ACOP will be intermittently logically connected via the APS to the High Rate Frame Multiplexer (HRFM) for downlink of recorded data.

- 5.3 One (1) ACOP unit shall be installed 3-6 months prior to launch of the AMS-02 payload in order to provide time for payload checkout and communications system validation. One (1) middeck locker equivalent (MLE) of ACOP soft stowage hardware shall accompany this ACOP core unit to station along with the required fiber optic cables. It is highly desired that this ACOP unit and supporting hardware be delivered to ISS via Shuttle.
- 5.4 The spare ACOP flight unit can be transported to ISS as a phased delivery (it does not need to fly with the unit that will be installed in the EXPRESS Rack). The spare ACOP flight unit will be stowed in passive stowage onboard ISS and will be accessible by the crew for swap out with the installed unit within a reasonable timeframe should the installed unit fail. Shuttle launch of this spare ACOP flight unit is preferred, but is not a requirement. Following the spare ACOP flight unit's arrival on ISS, the AMS-02 Project may request that the unit be operationally checked-out within the ISS scheduling and resource constraints.
- 5.5 The ACOP payload requires crew time to replace 4 hard drives approximately every 20 days. This equates to 18 hard drive swap events per year for the duration of the AMS-02 nominal mission. Resupply logistics sparing, on-orbit stowage, and return manifest traffic modeling should account for the required use of 72 hard drives per year. The AMS-02 Project agrees to develop and validate a traffic model against the on-orbit use and stowage requirements.

## **5.6 PAYLOAD OPERATIONS CONTROL CENTER (POCC) REQUIREMENTS**

Due to the investment that the ISS Program and NASA are making to prepare, integrate, and manifest the AMS-02 and ACOP payloads for data collection onboard ISS, and due to the Marshall Space Flight Center (MSFC) Payload Operations Integration Center's (POIC) limited insight into AMS-02 payload operations and/or payload health and status data, the AMS-02 Project Office agrees to develop operations procedures and a standardized set of criteria to certify the AMS POCC console operators that will interface with the MSFC POIC throughout the life of the AMS-02 mission, including ACOP on-orbit operations. These requirements may be defined within an AMS-02 operations document with ISS Program concurrence.

- 5.6.1 The procedures and certification criteria shall include:

- 5.6.1.1 Communications protocol training for console operator positions interfacing with the MSFC POIC.
- 5.6.1.2 A defined set of payload telemetry parameters that require MSFC POIC notification should the parameters deviate from a nominal condition.
- 5.6.1.3 A set of detailed troubleshooting flowcharts and/or fault trees that describe where payload troubleshooting efforts will require additional ISS resources such as power, vehicle attitude changes, communications bandwidth, or crew time.

## 6.0 PROGRAM FURNISHED EQUIPMENT

This section of the PIA documents the AMS Project Office's requirements for ISS Program Furnished Equipment (PFE) to support ground and flight activities. The ISS Program will review, approve, and provide all decals.

### 6.1 GROUND REQUIREMENTS

The AMS-02 Project Office has the following Program Furnished Equipment Ground Requirements, Table 6.1-1.

**TABLE 6.1-1 PROGRAM FURNISHED EQUIPMENT GROUND REQUIREMENTS**

EQUIPMENT	QUANTITY	NEED DATE	DURATION	EQUIPMENT-SPECIFIC NOTES
Suitcase simulator (SCS)	1	9/1/05	3 months	Coordinate shipment through JSC AMS-02 Project Office
Taxiscope	1	9/1/05	3 months	Coordinate shipment through JSC AMS-02 Project Office
ERI	1	6/1/05	12 months	Purpose: software testing Coordinate shipment through JSC AMS-02 Project Office
NBOE14-4PNT	2	6/1/05	Payload lifetime	ISS Locker Power Connector, Flange Mount Required for Engineering Model and Qualification Model development
MS27468T15F 35P	4	6/1/05	Payload lifetime	ISS Locker Data Connector, Jam Nut Receptacle Required for Engineering Model and Qualification Model development

## 6.2 FLIGHT REQUIREMENTS

The AMS-02 Project Office has the following Program Furnished Equipment Flight Requirements, Table 6.2-1.

**TABLE 6.2-1 PROGRAM FURNISHED EQUIPMENT FLIGHT REQUIREMENTS**

EQUIPMENT (A)	QUANTITY (B)	NEED DATE (C)	DURATION (D)	EQUIPMENT-SPECIFIC NOTES (E)
NBOE14-4PNT	2	6/1/05	Payload lifetime	ISS Locker Power Connector, Flange Mount Required for Flight Hardware development
MS27468T15F 35P	4	6/1/05	Payload lifetime	ISS Locker Data Connector, Jam Nut Receptacle Required for Flight Hardware development

## 7.0 GROUND DATA SERVICES REQUIREMENTS DURING FLIGHT OPERATIONS

### 7.1 PAYLOAD DEVELOPER-REQUESTED GROUND DATA SERVICES REQUIREMENTS DURING FLIGHT OPERATIONS

Reference the contents of Table 7.1-1, Ground Data Services Requirements During Flight Operations for ACOP mission and resource requirements for flight operations.

**TABLE 7.1-1 GROUND DATA SERVICES REQUIREMENTS DURING FLIGHT OPERATIONS**

GROUND DATA SERVICES REQUIREMENT	LOCATION FROM	LOCATION TO	DATA RATE (kbps)	POIC PROCESS DATA	VOICE DISTRIBUTION SYSTEM	INTERNET VOICE DISTRIBUTION SYSTEM
Experiment Sci/Eng Data	POIC	AMS POCC	20 Mbs <sup>[1]</sup> Peak (Ku- band)	N		
AMS/ACOP Payload Health and Status Data	POIC	AMS POCC	10 bytes per sec (S-band)	N		
Voice	POIC/MCC	AMS POCC				Y
ISS Downlink Video						

Ground Commanding	AMS POCC					
POIC Services		AMS POCC				

Note [1]: Data rates are aggregated with the AMS-02 payload. The truss-mounted AMS-02 component creates an average of 2 Mbits/second of data. ACOP records this data regardless of the downlink status of AMS-02. ACOP can be requested to downlink portions of the recorded AMS-02 data. The typical aggregate downlink data rate of ACOP and AMS-02 should be modeled at 3 Mbits/second continuous.

## 7.2 ADDITIONAL REQUIREMENTS/SERVICES DURING FLIGHT OPERATIONS

Table 7.2.1 documents the additional ACOP requirements/services needed during simulations and real-time on-orbit operations.

**TABLE 7.2-1 ADDITIONAL REQUIREMENTS/SERVICES DURING FLIGHT OPERATIONS**

ADDITIONAL REQUIREMENTS/ SERVICES
Launch coordination with the AMS-02 payload meeting SSP-57113 requirements. ACOP requires installation in a continuously powered EXPRESS Rack 3-6 months prior to the AMS-02 launch in order to perform payload checkout and validation of the communications links.
ACOP requires the installation of PD provided non-standard fiber-optic interconnect cables (with two (2) fiber optic OUT and one (1) fiber optic IN) for high data rate link (HDRL) connections between the ACOP and two HDRL J7 ports on the UIP. Since there is only one J7 port available per rack location, this payload must run a fiber optic connection from it's installed location to another adjacent rack location.
Near continuous APS connectivity for transmit and receive HRDL fibers to enable high data rate communications between the ACOP and the truss-mounted AMS-02 payload. The remaining transmit fiber is intermittently connected to the HRFM for downlink of recorded data.
ACOP requires near continuous power throughout the duration of the AMS-02 nominal mission. The AMS-02 payload capability to buffer data is minimal. Therefore, there is risk of losing critical event data during Ku-band outages when ACOP is unpowered.
The ACOP payload needs to be in an operational state throughout the duration of the AMS-02 nominal mission due to the nature of the data events that the payload is investigating. In the event of an ACOP payload hardware failure requiring crew intervention, the ACOP payload recognizes the constraints posed by crew scheduling and critical ISS systems activities – but requests that payload recovery procedures begin within 48 hours of the failure.

<p>The ACOP payload will require crewtime for recording media replacement approximately every 20 days during nominal operations. The media replacement cycle may be affected by the frequency or quantity of collected data events or by Single Event Upsets impacting the recording media.</p>
<p>ACOP requires periodic re-supply of recording media and return to Earth of the recorded media. Note: The ACOP payload is expecting to replace 4 hard drives every 20 days for nominal operations. This rate equates to 72 used hard drives per year for ascent and descent manifest allocations. The specific allocation per flight is dependant on the on-orbit stowage availability/capacity and the visiting vehicles traffic models. Contingency hard drives to protect for failures may increase this number.</p>

## APPENDIX A – OPEN WORK

Table B-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., **<TBD 4-1>** is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the issue is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above-described numbering scheme. Original TBDs will not be renumbered.

**TABLE A-1 TO BE DETERMINED ITEMS**

TBD	Section	Description	Status/Closure Date

Table B-1 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., **<TBR 4-1>** is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above-described numbering scheme. Original TBRs will not be renumbered.

**TABLE A-2 TO BE RESOLVED ISSUES**

TBR	Section	Description	Status/Closure Date

## APPENDIX B

### ACRONYMS AND ABBREVIATIONS

ACOP	AMS Crew Operations Post
AMS	Alpha Magnetic Spectrometer
CERN	Center European Research Nuclear, Geneva, Switzerland
CTB	Cargo Transfer Bag
DIMS	Digital Imagery Management System
DOC	Department of Commerce
DOE	Department of Energy
DOS	Department of State
DQA	Data Quality Assurance
EAR	Export Administration Regulations
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
ETOV	Earth-to-orbit vehicle
EXPRESS	Expedite the Processing of Experiments to Space Station
FIT	Functional Integration Test
GFE	Government Furnished Equipment
HOSC	Houston/Huntsville Operations Support Center
HRDL	High Rate Data Link
HRFM	High Rate Frame Multiplexer
H-II	H-II Transfer Vehicle
ICD	Interface Control Document
IP	Internet Protocol
IRD	Interface Requirements Document
ISPR	International Standard Payload Rack
ISS	International Space Station
IVA	Intravehicular Activity
IvoDS	Internet Voice Distribution System
JSC	Johnson Space Center
kbps	Kilobits-per-second
kg	kilogram
KSC	John F. Kennedy Space Center
L-	Launch minus
lbm	pound mass
LRDL	Low Rate Data Link
m <sup>3</sup>	cubic meter
min	minute
Mbps	Megabits-per-second
MCC-H	Mission Control Center-Houston
MDM	Multiplexer/Demultiplexer
MEIT	Multi Element Integration Test
MLE	Middeck Locker Equivalent



MSFC	Marshall Space Flight Center
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NLR	No License Required
OD	Orbiter Downlink
OIU	Orbiter Interface Unit
PD	Payload Developer
PGSC	Payload General Purpose Computer
PIA	Payload Integration Agreement
POCC	Payload Operations Control Center
POIC	Payload Operations and Integration Center
PTCS	Payload Test and Checkout System
SCI	Science
sec	second
SOC	Science Operations Center
SSP	Space Shuttle Program
STS	Space Transportation System
T-	Time minus
TBD	To-Be-Determined
TBR	To-Be-Resolved
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UIP	Utility Interface Panel
U.S.	United States
USOC	United States Operations Center
USOS	United States On-orbit Segment
USS	Unique Support Structure
VAMS	Video Access Management System
Vdc	Volts direct current
W	Watt